EE35XX: Introduction to Electric Vehicles

B.Tech. X Semester
B.tech.

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Course: EE 35XX	**Title: Introduction to Electric Vehicles**	**No. of Lecture. 1**
Course instructor: H J Khuman		**Room No.:**
Module 1: Fundamentals & Types of EVs		**Unit:1.1**

Topic (s): Definitions and core principles of electric propulsion, Spectrum of electrification: BEVs, PHEVs, HEVs, and FCEVs.

Duration: 1 hour

Reference:

1. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2 nd Edition, 2017.
2. Ali Emadi, “Advanced Electric Drive Vehicles (Energy, Power Electronics, and Machines)”, CRC Press, 2015.
3. John G. Hayes and A. Goodarzi, “Electric Powertrain - Energy Systems, Power electronics and drives for Hybrid, electric and fuel cell vehicles”, Wiley, 2018.

Objectives:

At the end of this lecture students are expected to

1. Categorise different electric vehicle architectures.
2. Explain the fundamentals of EV operating principles.
3. Evaluate appropriate EV applications based on energy sources and propulsion systems.

Evaluation questions:

1. What is EV?
2. State the types of EVs.
3. State operating principle of EV

Fundamentals & Types of EVs

- **Core Swap:** Replaces the internal combustion engine, fuel system, and complex transmission with a high-voltage battery pack, one or more electric motors, and a power electronics controller for energy management.

- **Simpler Drivetrain:** The electric motor delivers instant torque directly to the wheels, typically through a single-speed gear reduction, eliminating the need for a multi-speed transmission and enabling high mechanical efficiency.

- **Energy Recovery:** Uses regenerative braking to capture kinetic energy while slowing down, converting it back into electricity to recharge the battery, which improves efficiency and reduces brake wear.

- **Charging is Fueling:** The battery is replenished by plugging into an external power source, with speed determined by the charging level (Level 1/2 AC or DC Fast Charging) and the vehicle's onboard capabilities.

- **Main Types:** Includes BEVs (Battery Electric Vehicles, powered solely by a battery), PHEVs (Plug-in Hybrids, with both a battery and a gasoline engine), and HEVs (Hybrids, which cannot be plugged in).

Types of EVs

- **Battery Electric Vehicle (BEV):** Runs entirely on a battery charged from the grid; zero tailpipe emissions. Examples: Tesla Model 3, Nissan Leaf.

- **Plug-in Hybrid Electric Vehicle (PHEV):** Combines a medium-sized rechargeable battery with a gasoline engine. It can drive a significant distance (typically 20-50 miles/30-80 km) on electricity alone before switching to hybrid operation. Must be plugged in to recharge the battery fully.

- **Hybrid Electric Vehicle (HEV):** Powered by both a gasoline engine and a small electric motor, with the battery charged solely by the engine and regenerative braking. It cannot be plugged in, and the electric motor primarily assists the engine to improve fuel economy.

Battery Electric Vehicle (BEV)

- Pure Electric Powertrain: Operates solely on electricity stored in a large, high-voltage battery pack, powering one or more electric motors to drive the wheels, with zero internal combustion engine.

- Dependent on Charging: Must be plugged into an external power source (home outlet, public charger) to recharge its battery. Range is determined by battery capacity (measured in kWh).

- Zero Tailpipe Emissions: Produces no exhaust pollutants (such as CO_2 and NO_x) during operation, making it a key technology for reducing local air pollution and greenhouse gas emissions.

- Highest Efficiency & Lower Running Costs: Converts over 77% of electrical energy to wheel power (vs. ~20% for gasoline). Has significantly lower "fuel" and maintenance costs due to fewer moving parts.

- Core Technology Challenges: Faces hurdles related to charging infrastructure availability, longer refuelling times compared to gasoline, and upfront cost largely tied to the battery.

- Defining Models: Represented by vehicles like the Tesla Model 3/Y, Nissan Leaf, and Volkswagen ID.4, which are designed from the ground up as electric vehicles.

Plug-in Hybrid Electric Vehicle (PHEV)

- Dual-Power Flexibility: Combines a rechargeable battery (typically 10-18 kWh) with a gasoline engine. Can operate as a pure electric vehicle for a limited range before seamlessly switching to hybrid mode.

- Must Be Plugged In: Requires connection to an external power source to achieve its full electric range and efficiency benefits. Without plugging in, it operates as a less efficient, heavier conventional hybrid.

- Best of Both Worlds (In Theory): Designed for short daily commutes on electricity (usually 20-50 miles/30-80 km) with zero tailpipe emissions, plus the long-distance capability of a gasoline engine for road trips without range anxiety.

- Higher Cost & Complexity: More expensive than a Hybrid (HEV) due to its larger battery, charging hardware, and more complex dual powertrain management system.

- Efficiency Depends on Use: Delivers maximum fuel savings and environmental benefit only if regularly charged. For drivers who rarely plug in, it becomes a heavier, less efficient gasoline vehicle.

- Common Examples: Include the Toyota RAV4 Prime, Ford Escape PHEV, and Chrysler Pacifica Hybrid, often marketed as a practical bridge technology for those not ready for a fully electric vehicle.

Hybrid Electric Vehicle (HEV)

- Self-Charging Hybrid: Cannot be plugged in; the battery is charged only by the internal combustion engine and through regenerative braking while driving, making it self-sufficient.

- Fuel Efficiency Focus: Designed primarily to enhance fuel economy and reduce emissions from a gasoline engine by using the electric motor to assist during acceleration, at low speeds, or at idle, not for pure electric driving.

- Limited Electric-Only Operation: Typically cannot drive on electricity alone for more than a mile or two, and only at very low speeds. The electric motor's primary role is to support and optimise the operation of the gasoline engine.

- Lower Complexity & Cost (vs. PHEV/BEV): Uses a much smaller, less expensive battery than a PHEV or BEV, resulting in a lower purchase price and no need for charging infrastructure or home installation.

- Transition Technology: Often seen as a "gateway" to electrification, as it introduces hybrid technology with no change in driver behaviour—you fuel it like a regular gasoline car.

- Iconic Example: The Toyota Prius is the most famous pioneer, with most major automakers now offering HEV versions of their popular gasoline models (e.g., Hyundai Tucson Hybrid, Ford Escape Hybrid).

Thank you!
Any Questions?